Once the ultimate grid size is established, BCPM 3.0 maintains certain features of the loop engineering design in BCPM 1.1. However, significant changes have been made to BCPM 1.1. BCPM 3.0 has abandoned the assumption that all customers are uniformly distributed throughout the CBG. (A discussion of changes from BCPM 1.1 to BCPM 3.0 is included in Appendix C)

The FCC's Further Notice of Proposed Rulemaking (FNPRM) released July 18, 1997 established a process for evaluating the BCPM and Hatfield models with the objective of developing a platform that meets the FCC's specified criteria.[4] As part of the FNPRM process, the FCC staff issued a Public Notice on September 3, 1997 prescribing guidelines regarding switching, transport, and signaling that cost proxy models under consideration should comply with. These guidelines included requirements to "permit individual switches to be identified as host, remote, or stand-alone";[5] "employ separate cost curves for host, remote and stand-alone switches";[6] employ algorithms that include switch capacity constraints;[7] and design an interoffice network that accommodates host, remote and stand-alone switches.[8]

The enhanced BCPM 3.0 is in compliance with all aspects of the guidelines proposed by the FCC staff in the September 3rd, Public Notice. The switch module designs a network of host, remote, and stand-alone switches based on the actual in place network and then uses separate cost curves for switch types and individual switch investment categories to develop the forward looking cost per line. The module analyzes input data files to determine whether switch capacity constraints have been exceeded for a wire center, and if so, places an additional switch in that wire center. The transport

[4] FCC Further Notice of Proposed Rulemaking, In the Matter of Federal-State Joint Board on Universal Service, CC Docket No. 97-45 and Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket No. 97-160.

[5] FCC Public Notice, "Guidance to Proponents of Cost Models in Universal Service Proceedings: Switching, Interoffice Trunking, Signaling, and Local Tandem Investment," CC Docket Nos. 96-45 and 97-160 released September 3, 1997, page 2.

[6] Ibid., page 3.

[7] Ibid., page 4.

[8] Ibid., page 5.

module designs efficient SONET rings for the modern network designed in the switch module based on characteristics of the actual in place network.

On November 13, 1997, the FCC released a Public Notice on Customer Location and Outside Plant.[9] This notice requires model proponents to modify their models to accommodate the new guidelines, to submit their revised models to the FCC, and to provide model cost runs for Florida, Georgia, Maryland, Missouri and Montana by December 11, 1997. The BCPM sponsors will meet these requirements. This model methodology document will be updated as needed.

BCPM 3.0 methodology is presented in the following sections:
Customer Location---Section 5.0
Outside Plant---Section 6.0
Switching---Section 7.0
Transport---Section 8.0
Signaling---Section 9.0
Support Plant---Section 10.0
Capital Costs---Section 11.0
Operating Expenses---Section 12.0
Report Module---Section 13.0

[9] FCC Public Notice, "Guidance To Proponents of Cost Models in Universal Service Proceedings: Customer Location and Outside Plant," CC Docket Nos. 96-45 and 97-160, November 13, 1997.

SECTION 2.0

BCPM 3.0 Attains the FCC's 10 Criteria

The FCC Universal Service Order invites states to submit universal service cost studies that are consistent with its ten model criteria.[10] At paragraph 206 the FCC Universal Service Order states: "Accordingly, to determine the appropriate level of federal support for service to rural, insular, and high cost areas, we invite states to submit cost studies consistent with the criteria that we prescribe herein and subject to Commission review and approval. State studies must be based on forward-looking economic cost, be consistent with the study used for the state universal service program, and not impede the provision of advanced services."

Paragraph 250 of the FCC Universal Service Order outlines ten criteria that are consistent with the eight criteria set out in the Joint Board recommendation.[11] The ten criteria are presented in italics below. Following each criterion is a brief statement describing how BCPM 3.0 is consistent with the criterion.

(1) The technology assumed in the cost study or model must be the least-cost, most-efficient, and reasonable technology for providing the supported services that is currently being deployed. A model, however, must include the ILECs' wire centers as the center of the loop network and the outside plant should terminate at ILECs' current wire centers. The loop design incorporated into a forward-looking economic cost study or model should not impede the provision of advanced services. For example, loading coils should not be used because they impede the provision of advanced services. We note that the use of loading coils is inconsistent with the Rural Utilities Services guidelines for network deployment by its borrowers. Wire center line counts should equal actual ILEC wire center line counts, and the study's or model's average loop length should reflect the incumbent carrier's actual average loop length.

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[10] FCC Report and Order, In the Matter of Federal-State Joint Board on Universal Service, CC Docket No. 96-45, released May 8, 1997.

[11] See the Majority State Members' Second State High Court Report at pp. 2-6.

BCPM 3.0 satisfies this criterion by incorporating least-cost, most-efficient, and current technology. The BCPM uses forward looking technology including: fiber driven, integrated digital loop carrier systems; efficient copper/fiber cross-over points in feeder to reflect least-cost provision of feeder; digital switching at current network switch nodes; and SONET transport rings. Load coils are not utilized in the Model and the network is engineered to be compatible with advanced services.[12]

BCPM 3.0 utilizes more accurate wire center boundaries provided by Business Location Research (BLR). These wire center boundaries are populated at the Census Block (CB) level.

(2) A network function or element, such as loop, switching, transport, or signaling, necessary to produce supported services must have an associated cost.

Within BCPM 3.0, each network function has an associated cost. This includes the local loop from the drop to the distribution to the feeder to the switch, with transport signaling, support plant, and the associated capital costs and operating expenses. The algorithms which assure that sufficient plant and equipment are provided are clearly documented and verifiable within the Model software and methodology documentation.

(3) Only long-run forward-looking economic cost may be included. The long-run period used must be a period long enough that all costs may be treated as variable and avoidable. The costs must not be the embedded cost of the facilities, functions, or elements. The study or model, however, must be based upon an examination of the current cost of purchasing facilities and equipment, such as switches and digital loop carriers (rather than list prices).

BCPM 3.0 incorporates the forward-looking cost of purchasing and operating known and proven facilities, equipment, and technologies. While switch (i.e., wire center) locations are assumed to be fixed, no equipment or technology is assumed to be embedded or fixed; all equipment is assumed to be variable and avoidable. Forward-looking costs are based on material prices net of discounts rather than list prices for

[12] For example, maximum copper loop lengths and cable gauges are designed to be compatible with fax and dial-up modems.

equipment and material. The Model does not rely upon embedded costs for facilities, functions or elements.

(4) The rate of return must be either the authorized federal rate of return on interstate services, currently 11.25%, or the state's prescribed rate of return for intrastate services. We conclude that the current federal rate of return is a reasonable rate of return by which to determine forward looking costs. We realize that, with the passage of the 1996 Act, the level of local service competition may increase, and that this competition might increase the ILECs' cost of capital. There are other factors, however, that may mitigate or offset any potential increase in the cost of capital associated with additional competition. For example, until facilities-based competition occurs, the impact of competition on the ILEC's risks associated with the supported services will be minimal because the ILEC's facilities will still be used by competitors using either resale or purchasing access to the ILEC's unbundled network elements. In addition, the cost of debt has decreased since we last set the authorized rate of return. The reduction in the cost of borrowing caused the Common Carrier Bureau to institute a preliminary inquiry as to whether the currently authorized federal rate of return is too high, given the current marketplace cost of equity and debt. We will re-evaluate the cost of capital as needed to ensure that it accurately reflects the market situation for carriers.

BCPM 3.0 allows the user to select their own rate of return, utilize the FCC's recommended rate of return of 11.25%, or run the Model's default rate of return.

(5) Economic lives and future net salvage percentages used in calculating depreciation expense must be within the FCC-authorized range. We agree with those commenters that argue that currently authorized lives should be used because the assets used to provide universal service in rural, insular, and high cost areas are unlikely to face serious competitive threat in the near term. To the extent that competition in the local exchange market changes the economic lives of the plant required to provide universal service, we will re-evaluate our authorized depreciation schedules. We intend shortly to issue a notice of proposed rule making to further examine the Commission's depreciation rules.

BCPM 3.0 allows the user to establish or change economic lives and net salvage percentages by account categories. As discussed previously, BCPM 3.0 includes two sets of inputs. The first set of inputs uses economic lives and future net salvage percentages that are within the FCC-authorized range. The second set uses economic lives and future net salvage percentages potentially user by competitors.

(6) The cost study or model must estimate the cost of providing service for all businesses and households within a geographic region. This includes the provision of multi-line business services, special access, private lines, and multiple residential lines. Such inclusion of multi-line business services and multiple residential lines will permit the cost study or model to reflect the economies of scale associated with the provision of these services.

BCPM 3.0 includes residential and business access lines and makes adjustments for public and special access so that the network design incorporates the efficiencies and economies of scale that a provider of all basic access services in a given geographic area enjoys.

(7) A reasonable allocation of joint and common costs must be assigned to the cost of supported services. This allocation will ensure that the forward-looking economic cost does not include an unreasonable share of the joint and common costs for non-supported services.

BCPM 3.0 allows the user to input either a common cost factor or expenses on a per line basis. The BCPM Sponsors included a reasonable allocation of joint and common costs in BCPM 3.0.

(8) The cost study or model and all underlying data, formulae, computations, and software associated with the model must be available to all interested parties for review and comment. All underlying data should be verifiable, engineering assumptions reasonable, and outputs plausible.

The user can view all inputs and a large number are easily adjustable by the user. All formulas and algorithms are available to the user and all interested parties for review and comment. The underlying data are verifiable and the engineering assumptions are reasonable and based on actual experience in installing state-of-the-art networks and technology.[13] The current version of BCPM can be downloaded from the BCPM web site, WWW.BCPM2.COM. In addition, copies of the BCPM Methodology, the Users Manual, a Systems Manual and a Model Input Guide are currently available at the web site.

(9) The cost study or model must include the capability to examine and modify the critical assumptions and engineering principles. These assumptions and principles include, but are not limited to, the cost of capital, depreciation rates, fill factors, input costs, overhead adjustments, retail costs, structure sharing percentages, fiber/copper cross-over points, and terrain factors.

BCPM 3.0 allows the user to examine and modify all of the variables listed in the criterion and many others either though easy to use drop down menus or through direct access to the EXCEL spreadsheets. BCPM 3.0 provides methods to process multiple financial, engineering, investment and expense views for the jurisdiction chosen. This provides the user with a great deal of flexibility in performing multiple scenario analysis.

(10) The cost study or model must deaverage support calculations to the wire center serving area level at least, and if feasible, to even smaller areas such as a Census Block Group, Census Block, or grid cell. We agree with the Joint Board's recommendation that support areas should be smaller than the carrier's service area in order to target efficiently universal service support. Although we agree with the majority of the commenters that smaller support areas better target support, we are concerned that it becomes progressively more difficult to determine accurately where customers are located as the support areas grow smaller. As SBC notes, carriers currently keep records of the number of lines served at each wire center, but do not know which lines are associated with a particular CBG, CB, or grid cell. Carriers, however, would be required to provide verification of customer location when they request support funds from the administrator.

BCPM 3.0 provides estimates of universal service costs at areas as small as variable grids. The BCPM 3.0 relies upon information at the census block level, rather than the much larger census block groups (CBGs). There are typically over 30 CBs per

[13] The underlying data are verifiable to the extent possible, given vendor constraints and the confidential nature of some of the information necessary to reflect genuine current expenditures.

CBG. BCPM 3.0 also utilizes more accurate wire center boundaries provided by BLR and more accurate translations of data to the wire center level. Therefore, BCPM 3.0 satisfies criterion 10 and provides estimates at a finer level of geographic detail.

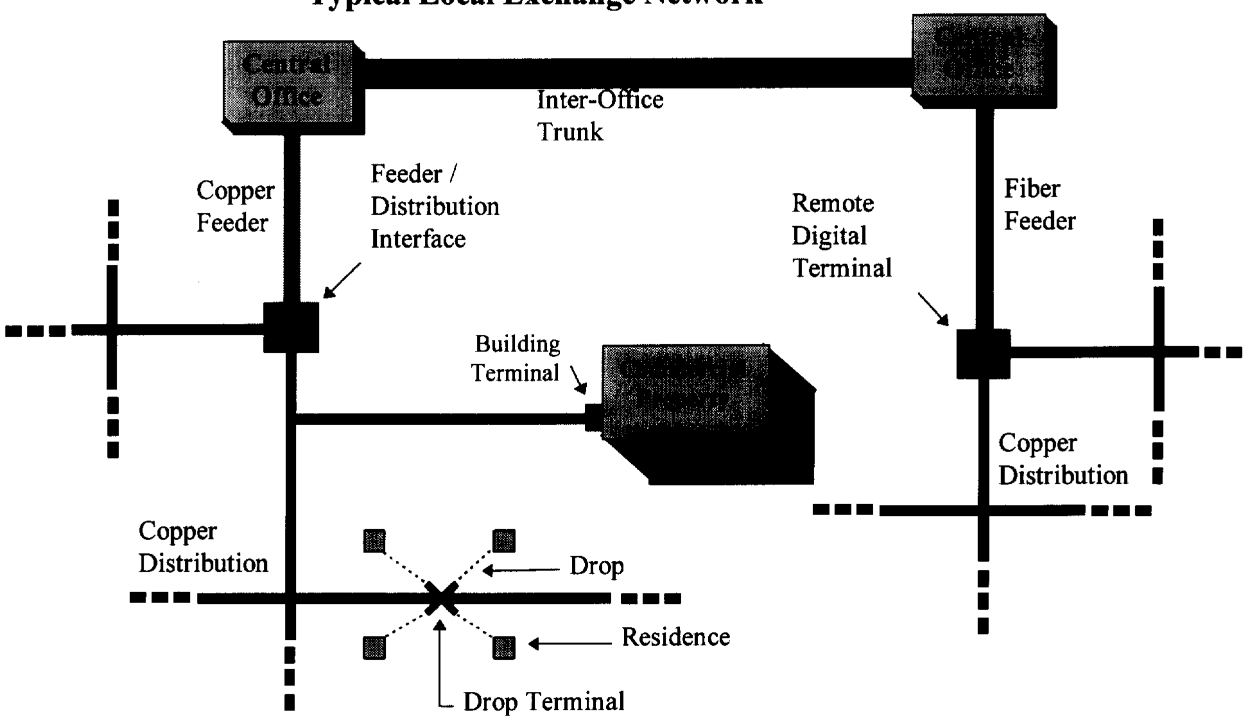
SECTION 3.0

THE NETWORK

3.1 Description of the Local Exchange Network

The following figure depicts the elements of a typical local exchange network.

Typical Local Exchange Network



The public voice grade local exchange network is designed to provide an instantly available (under most circumstances) 3,500 Hertz telecommunications channel between any pair of users attached to the network. Components of the network are designed to meet minimum transmission characteristics for noise, echo return loss, envelope delay distortion, as well as other quantifiable objectives for transmission quality. Many of these minimum transmission standards are met through basic engineering design criteria that specify the standard electrical and transmission characteristics for individual network components and groups of components. The following description traces a call on the public voice grade network from an originating customer premise through the network to terminate the call at a second customer premise.

Before a call can be initiated, a customer must have a telephone set, which is connected to the public voice grade network. The customer's telephone plugs into the wall to wiring also owned by the customer. The wiring in each residence and business premise is connected to the network through a telephone company owned interface device located at the customers' premise. Single family housing units generally use a basic network interface device (NID), typically a small gray box located on the outside of the house, while a large commercial building has a building terminal designed to accommodate terminations for multiple customers. These interface devices connect the public voice grade telephone network to the customer-owned wiring and telephone sets.

Once the customer lifts the phone receiver, call connection to the public telephone network begins. At the point the receiver is lifted, a connection is made to the telephone company switch at the central office. This connection starts at the telephone set, through the inside wire, through the network interface device (NID), which connects to a drop wire. The drop wire consists of two or three pairs of copper wires, which permanently connect the house to a drop terminal. In densely populated areas the drop wires from several residences meet at a drop terminal. The drop terminal is where the drop wires are connected to a larger cable that connects many houses in a similar manner. This cable is called a distribution cable. The distribution cable then connects to a feeder/distribution interface, commonly called an FDI. The FDI connects many distribution cables to a feeder cable. The feeder cable goes to the central office location where it is connected to the telephone switch through a main distribution frame.

The connection to the switch is initiated by the customer lifting the phone receiver. The switch, which is really a large computer, acknowledges the customer action by providing dial tone to the customer, thereby notifying the customer that the switch is ready to receive the telephone number of the party where the call is to be completed. The customer enters the number by "dialing" through the telephone set. The switch interprets the tones or pulses into a terminating location on the network. The switch "looks up" the terminating location in a data base that tells the switch where to physically route the call. In this case, the call is connected to a local inter-office trunk group that connects one central office location to another central office in the local calling area. Call traffic is consolidated and switched at telephone company central offices, which are connected with each other via high capacity trunks (usually optical fiber).

At the terminating switch, the terminating call number is translated to a customer location. The terminating switch generates a ringing signal to the terminating location. In this case, the signal follows a path in the switch to a digital channel of a fiber optic feeder route to a remote terminal. At the remote terminal the optical channel signal is converted into a digital electrical signal, and then converted to an analog electrical signal on the pair of copper wires that connects through an FDI, distribution cables, terminals, drop wire, and NID at the terminating location. The phone at the receiving location rings, at which point the receiving party may pick up his or her phone, completing the call.

3.2 Technical Capabilities of the BCPM 3.0 Network

BCPM 3.0 designs a voice grade network using state-of-the-art technology that is currently available for deployment. The BCPM 3.0's default values and parameters provide a network capable of providing basic single-party voice grade service that allows customers to utilize currently available data modems for dial-up access. BCPM 3.0 designs the network to eliminate problems associated with providing voice grade service over loaded loop plant.

In order to design a least cost network that provides adequate transmission capabilities for fax and dial-up modems, BCPM 3.0 designs an outside plant system that typically maximizes loop lengths for copper at 12,000 feet for both feeder and distribution. This eliminates problems arising from loading and resistance. BCPM 3.0 uses 26/24 gauge cable in the feeder and 26/24 gauge in the distribution. 12,000 ft of 26 gauge copper has a resistance value of 999.6 ohms (83.3 ohms per thousand feet @ 68deg.), well within the 1500 ohm supervisory limit of today's digital switches. The 26/24 gauging used in the distribution takes into account the 900 ohm powering limitations of DLC line cards, without going to the considerably more expensive extended range line cards. In the few cases where BCPM 3.0 does allow copper loops of up to 18,000 feet in the distribution network, 24 gauge cable (with extended range line cards for distribution distances over 13,600 feet) is used to serve all customers in the distribution area. Where feeder runs exceed 12,000 feet, BCPM 3.0 uses fiber cables.

The typical 12,000 foot loop, along with a loop network design that avoids bridged-tap, also removes capacitance concerns. Avoiding bridged-tap is accomplished by tapering and placing FDIs. The 12,000 foot design also facilitates the provisioning of services up to DS1. Additionally, BCPM 3.0 uses digital loop carrier systems for voice grade services rather than analog copper facilities when demand within a grid exceeds the capacity of copper cables.

Cable fills that are found in the BCPM 3.0 tables allow for proper network design. These cable fills allow maintenance operations to cost-effectively deal with defective pairs and administer customer turnover. The default values take into account that a new network is constructed to serve existing households (a snapshot view) with provisions for administrative and repair needs.

BCPM 3.0 designs a network of digital host, remote and stand-alone switches based on the actual in-place network. DMS-100 and 5ESS switches are used in the design process. Moreover, the user has the ability to specify a switch vendor. Actual data on subscriber calls and usage for business and residence customers are used to design a busy hour grade of service.

The interoffice network uses SONET rings in currently commercially available ring sizes (OC3, OC12 or OC48). Redundancy is provided through "self healing rings" connecting the tandem/host/remote switches.

SECTION 4.0

OVERVIEW OF THE BCPM 3.0 MODEL

4.1 Model Structure

BCPM 3.0 is comprised of a series of modules in functional areas pertinent to the design and costing of a foreword looking telecom network. These modules include:

- Preprocessor Module formats some of the raw input data for further processing, identifies the locations of customers within the wire center, and builds the grid system and feeder plant routes used to design the distribution cable system. (Customer Location methodology is discussed in depth in Section 5.0.)
- Outside Plant Module designs and costs the distribution cable system. (Outside Plant methodology is discussed in depth in Section 6.0.)
- Switch Module designs and costs the digital network of host/remote /standalone switches based on the locations of the actual in-place network. (Switch Module methodology is discussed in depth in Section 7.0.)
- Transport Module designs and costs the SONET interoffice transport system. (Transport Module methodology is discussed in depth in Section 8.0.)
- Capital Cost Module develops depreciation, rate of return, and tax factors and applies them to the investment accounts to produce the capital cost. (Capital Cost Module methodology is discussed in depth in Section 11.0.)
- Operating Expense Module determines the annual expense cost attributable to providing universal service. (Operating Expense Module methodology is discussed in depth in Section 12.0.)
- Report Module summarizes the results of the previous modules. (The Report Module is discussed in Section 13.0)

4.2 Model Inputs

For most of the inputs in the Model the user has three options; they can develop their own inputs, accept the default inputs developed by the Model's sponsors, or use a combination of user inputs and model defaults.

For example, BellSouth, Sprint, and U S WEST - the Joint Sponsors of BCPM 3.0, who collectively provide service to over 30 states, have provided an industry-wide composite of current material, installation, and structure prices for individual network components that are used in the Model. This includes the prices for cables, digital loop carrier equipment, switches, feeder/distribution interfaces, manholes, poles, etc. These figures allow BCPM 3.0 to use the widest possible base of data of equipment and installation prices currently paid by LECs.

Additionally, the Joint Sponsors have provided an industry-wide composite of forward-looking operational and overhead expenses by account that are specifically associated with the provision of basic local exchange service. The Operating Expense module allows these forward-looking operational expenses, which are stated on a per line basis, to be adjusted by the user according to individual account. The Joint Sponsors also developed industry-wide, forward-looking cost of capital and depreciation lives by account. These are used in the BCPM 3.0's Capital Cost module and are fully user adjustable.

4.3 Model Flexibility

Finally, BCPM 3.0 provides methods to process multiple investment and expense views across multiple states. This provides the user with a great deal of flexibility in performing multiple scenario analysis.

A summary of the changes from BCPM 1.1 incorporated in BCPM 3.0 is included in Appendix C.

SECTION 5.0

CUSTOMER LOCATION METHODOLOGY

5.1 Introduction

BCPM 3.0's customer location algorithm selects the appropriate granularity of analysis to assure that customers are accurately located and moreover, that the cost outputs are representative of the network design necessary to serve those customers. BCPM 3.0's use of actual data to determine the location of customers provides network costs that are more accurately measured, which, in turn, allows efficient targeting of high-cost areas.

BCPM 3.0's customer location algorithm addresses the recognized deficiency of the Census Block Group (CBG) as an engineering unit in rural areas. Instead, by going to the Census Block (CB) level, BCPM 3.0 reflects the reality of rural areas; that is, that people are not necessarily dispersed equally throughout the CBG. By overlaying wire centers with grids, BCPM 3.0 constructs a network that avoids building to areas where people are unlikely to reside, concentrating instead, on road miles where people are more likely to be located.

5.2 BCPM 3.0 Enhancements

BCPM 3.0 integrates more precise information regarding customer location with a clustering algorithm that reflects an efficient network design, given technological constraints of the telephone network.

A previous version of BCPM, BCPM 1.1, based customer location on Census data at the CBG level. BCPM 1.1 assigned CBGs to wire centers based on whether the centroid, i.e. geographic center, of the CBG fell within the wire center boundaries provided by On Target's "Exchange Info Plus" data product. This all or nothing CBG assignment resulted in a significant number of misassignments of customers to wire centers, as well as misassignments of customers to their respective local exchange carrier.

BCPM 3.0 utilizes Census data at the CB level. CBs reflect customer location at a much more granular level than CBGs. This increased level of granularity provides greater assurance of truly locating customers and assigning customers to the proper wire center. Additionally, BCPM 3.0's use of wire center boundaries provided by Business Location Research (BLR) increases the accuracy in assigning customers to their actual serving wire center.

BCPM 3.0 recognizes that telephone plant engineers do not typically build plant on a customer by customer basis. Rather, they plan and build plant based on Carrier Serving Areas (CSAs)[14] and Distribution Areas (DAs). Thus, engineers recognize actual clustering of customers when implementing standard engineering practices that try to maximize the efficient use of plant, minimize the distribution portion of plant, and ensure adequate service quality. One of the major challenges of building a proxy model is clustering customers in a fashion that integrates engineering practices based on this CSA and DA approach.

The BCPM 1.1 and earlier versions, including BCPM 1.0, Benchmark Cost Model 2 (BCM2), and BCM, as well as Hatfield 4.0 and its earlier versions, used the CBG as the unit of engineering area. Our analysis indicates that CBGs have substantial deficiencies as a modeling unit. These deficiencies exist mainly in rural areas. In these sparsely populated areas, CBGs tend to be rather large and odd in shape, and provide no information about where customers are truly located.

To adjust for these deficiencies, the modelers of both BCPM and Hatfield developed various approaches to recognize the actual location of customers. BCPM 1.1 used a road reduction approach that reduced the area engineered to a 500-foot buffer along each side of roads within the CBG. Hatfield uses a town clustering approach that assumes a given percentage of rural customers reside in town (typically 85%). Hatfield assumes that the customers in town are located in 2 or 4 sub-clusters where customers

[14] A CSA encompasses the entire design area potentially served from a particular digital loop carrier (DLC) site, including the feeder distribution interface, vertical and horizontal connecting cables, backbone cable and branch cables.

live on contiguous 3-acre lots. Furthermore, Hatfield assumes that the remaining customers (typically 15%) are located 150 feet from a few road cables that emanate from these sub-clusters.

However, neither the BCPM 1.1 nor the Hatfield 4.0 rural approaches captured actual customer location with adequate accuracy. Given this dilemma, the BCPM developers recognized the need to create an innovative approach that could locate accurately customers in all areas. To accomplish this, BCPM 3.0 uses a reformulated geographic entity - the dynamic grid.

The Cost Proxy Model (CPM©) used a 1/100 of a degree longitude and latitude grid. This standardized the geographic unit of measure for modeling, simplified the engineering algorithms, removed the modeling errors from "squaring" CBGs, and allowed the roll-up of the geographic grid entity into almost any entity desired by the user. BCPM 3.0 further enhances the CPM's grid approach by combining it with CSA engineering constraints. The resulting grid unit is dynamic in the sense that this grid varies in size to ensure that the number of customers included in a grid takes into account CSA guidelines. Furthermore, the maximum grid size is constrained so that the limitations of copper distribution are not exceeded.

To illustrate the rural data and the various approaches to locating rural customers, Appendix A, Exhibit 1, provides satellite maps for six random CBGs in the lowest density group, i.e. less than five housing units per square mile. Note the variability in the degree of clustering across these CBGs. Appendix A, Exhibits 2 and 3, provide the comparison of Hatfield Model 4.0's, BCPM 1.1's, and BCPM 3.0's characterization of customer location for two of these six CBGs. Although this is not representative of all rural areas, these areas were randomly selected and seem to demonstrate BCPM 3.0's superiority in locating customers.

5.3 Methodology

The following discussion provides highlights of the methodology employed in generating the appropriate grid configuration associated with a given wire center. In general, a series of reaggregation steps subsequently combines grids into various sizes, consistent with an efficient network design. Each grid's size, cost characteristics, and number of lines is integrally linked to telephone engineering CSAs and DAs. In addition, the construction of these grids takes into account the actual road network to more accurately reflect the location of customers within a CB. (Additional detail on this process is provided in Appendix B.)

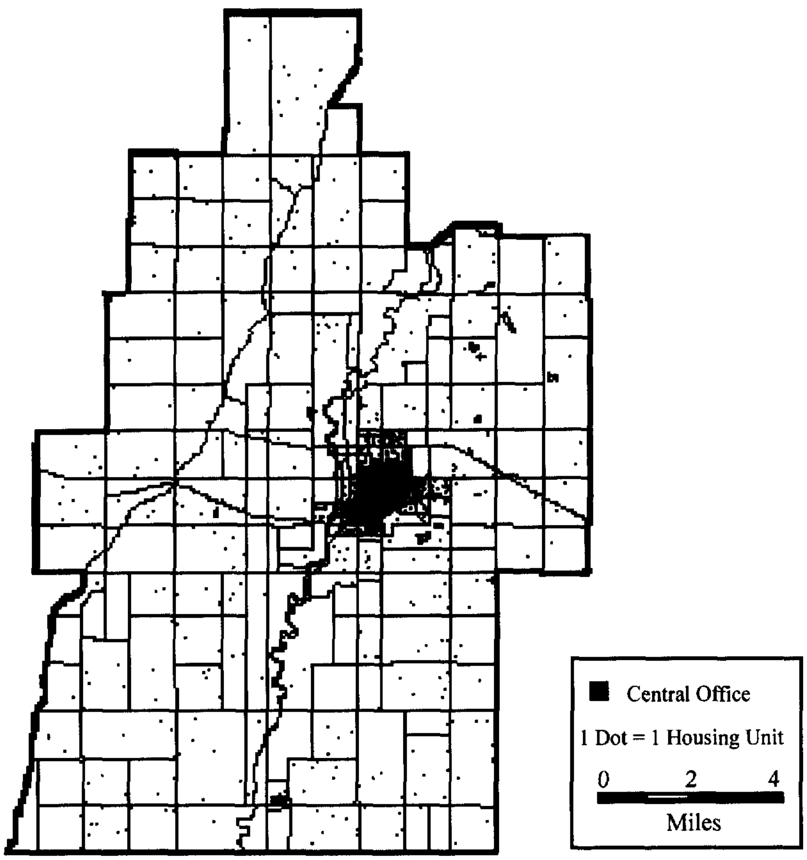
5.3.1 Wire Center Boundaries

The first step in accurately establishing customer location is the specification of the appropriate wire center boundaries. In BCPM 1.1, wire center boundaries were established based on the aggregate area of CBGs whose centroids were assigned to that particular wire center. In contrast, BCPM 3.0 relies on wire center data obtained from BLR. Appendix A, Exhibit 4, compares actual wire center boundaries with the wire center boundaries of BCPM 1.1 and BCPM 3.0 for an Iowa wire center.

The second step is to use the CB level of data that falls within the corresponding wire center boundary. For the occasional CB that crosses a wire center boundary, housing and business data is apportioned to the respective wire center based either on the proportion of land area, if the CB is less than 1/4 of a square mile, or the proportion of roads, if the CB is greater than 1/4 of a square mile. Appendix A, Exhibit 5, depicts CBs within the Waukon, Iowa wire center. Figure 5.1 (below) displays Census Blocks and Housing Unit Density for the Red Oak, Iowa Wire Center. The Bureau of the Census establishes CB boundaries based on roads and natural borders such as rivers. The CB data that provides household and housing unit line counts reflect 1990 Census data that have been updated based upon 1995 Census statistics regarding household growth by county. BCPM 3.0 also uses business line data obtained from PNR and Associates (PNR). Although some of the business lines are defined only at the Census Tract and CBG level,[15] PNR has successfully assigned approximately 85% of the business customers to specific CBs.

[15] This is typical of attempts to geocode customer locations based on address data.

[redacted]



The final step is the creation of the variable size grids from the CB data within the wire center boundaries. Appendix B provides greater detail regarding data specifications and the grid process/algorithms. The purpose of developing variable size grids is to simulate the basic telephone plant engineering units of a CSA and DA.

5.3.2 Establishing Microgrids

It is necessary to establish microgrids so that populated areas can be aggregated appropriately into telephone engineering CSAs and DAs. There are two phases of the grid process. The first phase entails assigning CB data to microgrids. "Microgrid" refers to the smallest grid size used in the grid process. A microgrid is 1/200th of a degree latitude and longitude. This corresponds to approximately 1,500 feet by 1,700 feet latitude and longitude.[16] The entire serving wire center is partitioned into microgrids. Thus, each CB within the serving wire center is overlayed with microgrids (unless the entire CB falls within a single microgrid). Smaller CBs, typically located in the denser, urban areas, are aggregated into microgrids while larger CBs located in the rural areas may span multiple microgrids.

Since household and business line data[17] are assigned at the CB level, this process requires apportioning CB line data to the corresponding microgrids. Two approaches are used to apportion this data to the microgrids, depending on the size of the CB. For CBs whose area is less than 1/4 of a square mile, (2,640 feet by 2,640 feet), encompassing approximately three to four microgrids, household and business line data is apportioned based on the land area of the microgrid used relative to the CB's total area.[18]

For CBs with an area greater than 1/4 of a square mile, household and business line data is apportioned based on relative road lengths using actual road data obtained from TIGER/Line files [Topologically Integrated Geographic Encoding and Referencing from the US Census Bureau]. That is to say, the line data is apportioned based on the road length contained within a microgrid that traverses that CB, relative to the total road length within that CB. Since roads are used to locate customers, certain roads where customers are unlikely to reside, have been excluded from the road data.[19] To illustrate

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[16] Due to the curvature of the earth, these dimensions vary depending on the latitude and longitude where they are derived. These measurements are used only to give the reader a sense of relative size.

[17] Household data includes housing unit and household information from the Census Bureau. Business line counts are obtained from PNR.

[18] For a microgrid that is fully encompassed by a CB, i.e. 100% of the microgrid's area is encompassed within the CB, the area covered by that one microgrid is (1,500ft. x 1,700 ft) = 2,550,000 sq. ft. If the total area of the CB is 5,100,000 sq. feet, then the fraction of land area of the CB encompassed by that microgrid is(2,550,000sq ft. /5,100,000sq. ft.) = .5 of the area. Thus, 50% of the household and business line data is apportioned to that microgrid.
If only a portion of a microgrid is encompassed by the CB, e.g. 80% of the microgrid is encompassed by the CB, then the area covered by that one microgrid is .8x(1,500ftx1,700ft) = 2,040,000 sq. ft. If the area of the CB is 5,100,000sq. ft., then (2,040,000 sq. ft./5,100,000 sq. ft.) =.40 In this case, .4 or 2/5ths of the household and business line data is apportioned to the microgrid.

[19] Road data used in BCPM 3.0 exclude all limited access highway segments; all highway and road segments that are in a tunnel or in an underpass; vehicular "trails" and roads passable only by 4 wheel drive vehicles; highway access ramps; ferry crossings; pedestrian walkways and stairways; alleys for service vehicles; and driveways and private roads.

the apportionment of household and business line data to microgrids based on relative road lengths, assume that the total road length associated with a particular CB is 60 miles and that 20 of those miles traverse a particular micrograd. Since (20 miles / 60 miles) = .333, 1/3 of the household and business line data is associated with that particular micrograd. At the end of phase one of the grid process, the total census housing unit and PNR business line data associated with a wire center have been apportioned to each of the micrograds comprising that serving wire center.

5.3.3 Reaggregating Micrograds into Grids

The second phase of the grid process entails aggregating these micrograds into larger grids as appropriate. The ultimate size of the larger grids depends upon housing and business line data and technological constraints on the reasonable size of CSAs. In general, the largest ultimate grid size is 1/25th of a degree latitude and longitude in size or approximately, 12,000 to 14,000 feet per side.[20] Hereafter, grids 1/25th of a degree latitude and longitude are referred to as macrograds. The macrograd constrains the maximum copper distribution length from the DLC to the customer to 12,000 feet, in most cases. Occasionally, however, due to placement of the DLC or re-aggregation of the isolated grids (discussed later), the length of a cable from the DLC to the customer may exceed 12,000 feet. In these cases cable gauge is adjusted from 26 to 24 gauge to accommodate distribution cable lengths up to 18,000 feet.

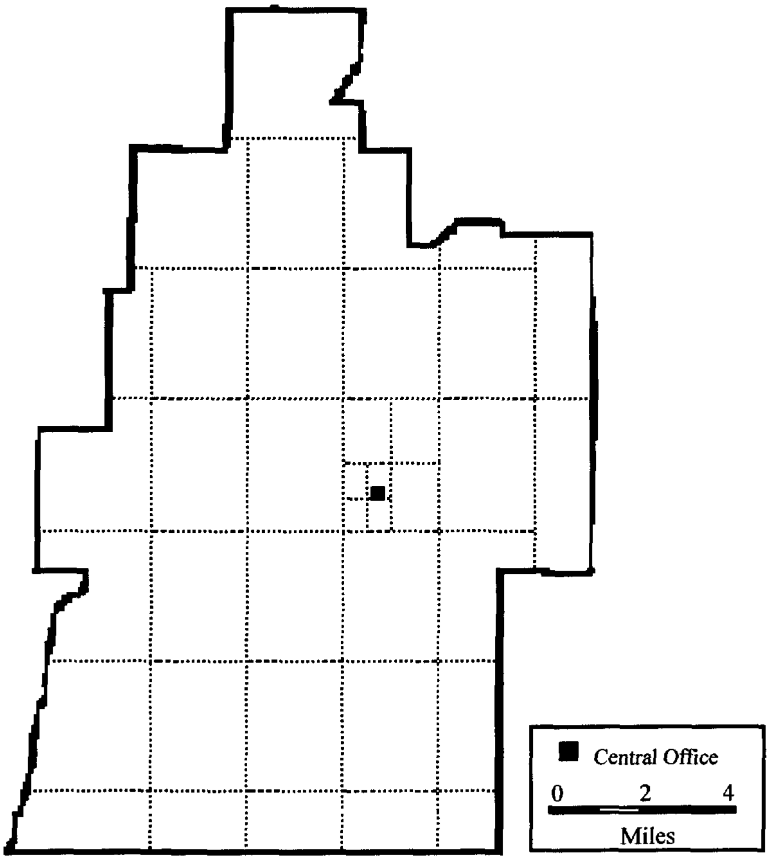
At first blush, it may seem reasonable to start with micrograds and expand them as appropriate to satisfy technological constraints. However, such an approach results in a large number of remaining micrograds dispersed among larger grids. To reduce the potential for isolated micrograds, BCPM 3.0 establishes fixed grid boundaries by overlaying macrograds upon the micrograds. A total of 64 micrograds constitutes a macrograd. These macrograd boundaries constitute the maximum size grid associated with each respective group of 64 micrograds.

[20] Ultimate grids may exceed this size if isolated grids are combined with grids 12,000 feet by 14,000 feet per side to generate an ultimate grid. (This is discussed later.)

The ultimate grid size utilized essentially reflects the manner in which customers are clustered. Modeling grids that vary in size is tantamount to allowing clusters of customers associated with a particular CSA to vary in density and dispersion.

The algorithm for determining the ultimate grids is actually a multistage process built to satisfy engineering constraints, minimize processing time, and simplify computer code. The following provides the essence of the grid algorithm. (For a more detailed discussion of the general rules for grid aggregation see Appendix B.) The derivation of grids is essentially an iterative process where partitioning occurs if the number of lines within a grid is too large, or if other technological constraints become binding. The macrogrid is partitioned into smaller grids, if warranted, based on household and business line data associated with the underlying microgrids, and CSA guidelines. The iterative process partitions the macrogrid into four equally sized subgrids. In some instances, these subgrids, which are $1/50^{th}$ of a degree latitude and longitude in size, become the ultimate size for that composite of microgrids. In other instances, the number of lines within a subgrid is still too large. In those instances, additional sub-partitioning occurs for the subgrids. Additional sub-partitioning continues to occur until all grids satisfy line size and technological constraints. The smallest grid allowed is the $1/200^{th}$ of a degree latitude and longitude, the microgrid. The resulting ultimate grids have a composite household and business line count equal to the sum of the household and business lines for the associated underlying microgrids. The ultimate grids for Waukon, Iowa are depicted in Appendix A, Exhibit 5. Ultimate grids for Red Oak, Iowa are shown in figure 5.2 (below).

[redacted]



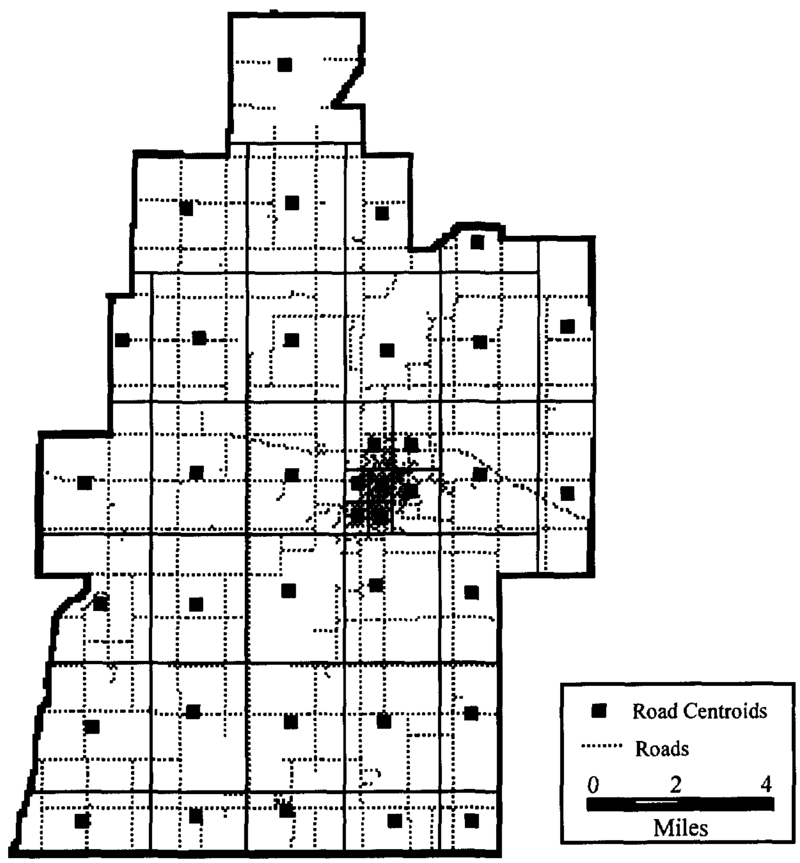
It is possible that, after completing this iterative process, small groups of isolated micrograms remain within the macrogrids, that have less than 100 lines associated with each group. Such isolated micrograms do not warrant placement of a CSA within a group. Instead, these small groups of micrograms are aggregated with ultimate grids within the macrogrid in which they reside, that are equal or larger in size, and are located closest to the road centroid of each small group of micrograms.

Partial grids arise from micrograms that intersect the wire center's boundaries and do not lie within a macrogrid. Partial grids with line demand less that 100 and smaller than 1/5th of a macrogrid in area, and therefore, not supportive of a CSA for that partial grid, are aggregated with the adjacent macrogrid that constitutes the longest border along that partial grid. The process described above is repeated for each expanded macrogrid.

5.3.4 Establishing Distribution Quadrants Within Each Grid

Once the ultimate grids have been established, each ultimate grid[21] is segmented into four distribution quadrants. Each quadrant represents a potential DA. The latitude and longitude coordinates of the distribution quadrants are determined by first establishing the road centroid of the grid.[22] Figure 5.3 (below) displays the road system and road centroids for ultimate grids in Red Oak, Iowa. Distribution quadrants within the ultimate grid are centered about this road centroid.

[redacted]



[21] Since data is not defined below the microgrid level, the microgrid cannot be segmented into quadrants.

[22] The road centroid is calculated as the average horizontal and vertical point of all roads in the defined area.

Within each distribution quadrant, another road centroid is established. If a distribution quadrant does not contain any roads, that distribution quadrant is simply treated as an empty distribution quadrant. For each non-empty distribution quadrant, the total area that falls within a 500-foot buffer along each side of the roads within that distribution quadrant is calculated. The DA is modeled as a square whose size is equal to the total road buffer area. The center of each distribution quadrant's square DA is placed at the road centroid of the distribution quadrant. (See Figure 5.4, below, for an example of quadrants for an ultimate grid in Red Oak, Iowa.) Such an approach provides a reasonable model of the required telecommunications network facilities for two reasons. First, households and businesses typically reside near roads and centering the distribution quadrant of the distribution area about the center of the roads establishes network facilities closer to where customers are located than does the geographic center of the distribution quadrant. Second, rights of way for telecommunications structure generally exist near roadways. This approach reduces requisite network facilities, given customers' actual location.